Using Geomatics in Urban Forestry

By Kieran Hunt

PAUL COWIE AND ASSOCIATES

consulting arborists / urban foresters

Kieran Hunt

- B.S. in Ecology, Evolution, and Natural Resource Management from Rutgers University, New Jersey
  - Certificate in Environmental Geomatics
- Urban Ecology and Geomatics
  - Paul Cowie and Associates, Inc.

Using Geomatics in Urban Forestry

- Using geographic data helps us manage urban forests effectively.
- Uses vector and raster data
- Involves learning map making.

Using Geomatics in Urban Forestry

- **Urban forestry**: managing urban trees on a forest level.
  - Large amounts of data / many trees.
  - Easy to overwhelm clients… or ourselves.
- Geomatics enhances management, communication, and ability to meet goals.
- The future of urban forestry!

What is Geomatics?

- **Geomatics**: the field of using, managing, and distributing geographically referenced (georeferenced) and associated information.

Isn't that "GIS"?

- **Geographic Information System** (**GIS**): any system for the management/distribution of georeferenced and associated information.
- Examples of Geographic Information Systems:
  - A hard copy spreadsheet of street trees and addresses.
  - A computer system containing satellite imagery of the entire world.

Geomatics Vs. GIS

- A **GIS** is a **system** for managing a **specific set** of geographically relevant data (for a specific project, location, field of study, etc.).
- **Geomatics** is the field of utilizing geographically relevant information, and includes the management of geographic information systems.

Types of Georeferenced Data

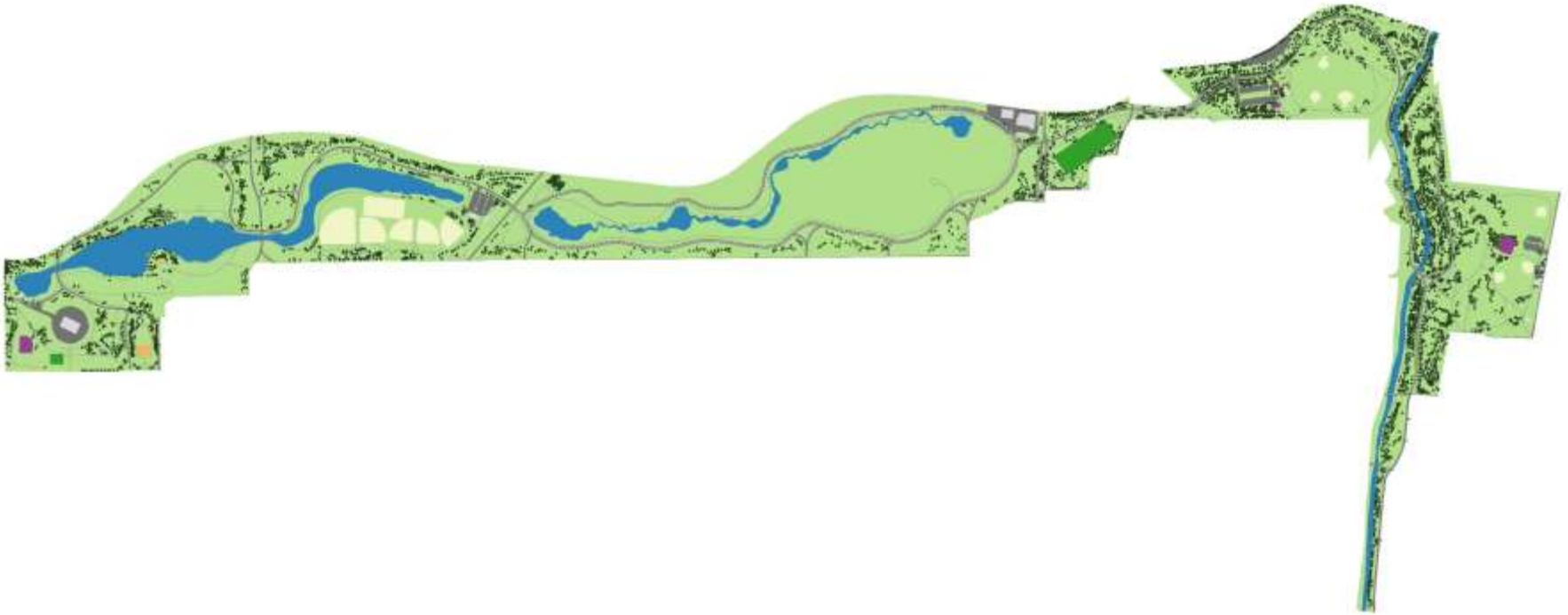
- **Discrete features** have defined locations on the ground, often represented by points or shapes:
  - Trees
  - Roads
  - Buildings
  - Planting sites
  - Property lines
- **Continuous data** are contained in a grid of **numeric values**:
  - Satellite imagery
  - Aerial photography
  - Elevation data

Types of Geographic Data: Vector Data

- **Discrete features**.
- Represented by:
  - Points
  - Lines
  - Polygons
  - Can have infinite **attribute** information
- **Feature**: a tree.
- **Attributes**: species, tag number, health, required maintenance work, planting site type, etc.

Vector Data

Branch Brook Park, Newark, New Jersey, USA



0 0.25 0.5 0.75 1 mi

Imagery derived from satellite orthophotography courtesy of the New Jersey OIT, OGIS (2012-2013).
Trees data collected by Kieran Hunt, Liz Stewart, Nick Cowie, and Paul Cowie of Paul Cowie and Associates, Inc.

Vector Data

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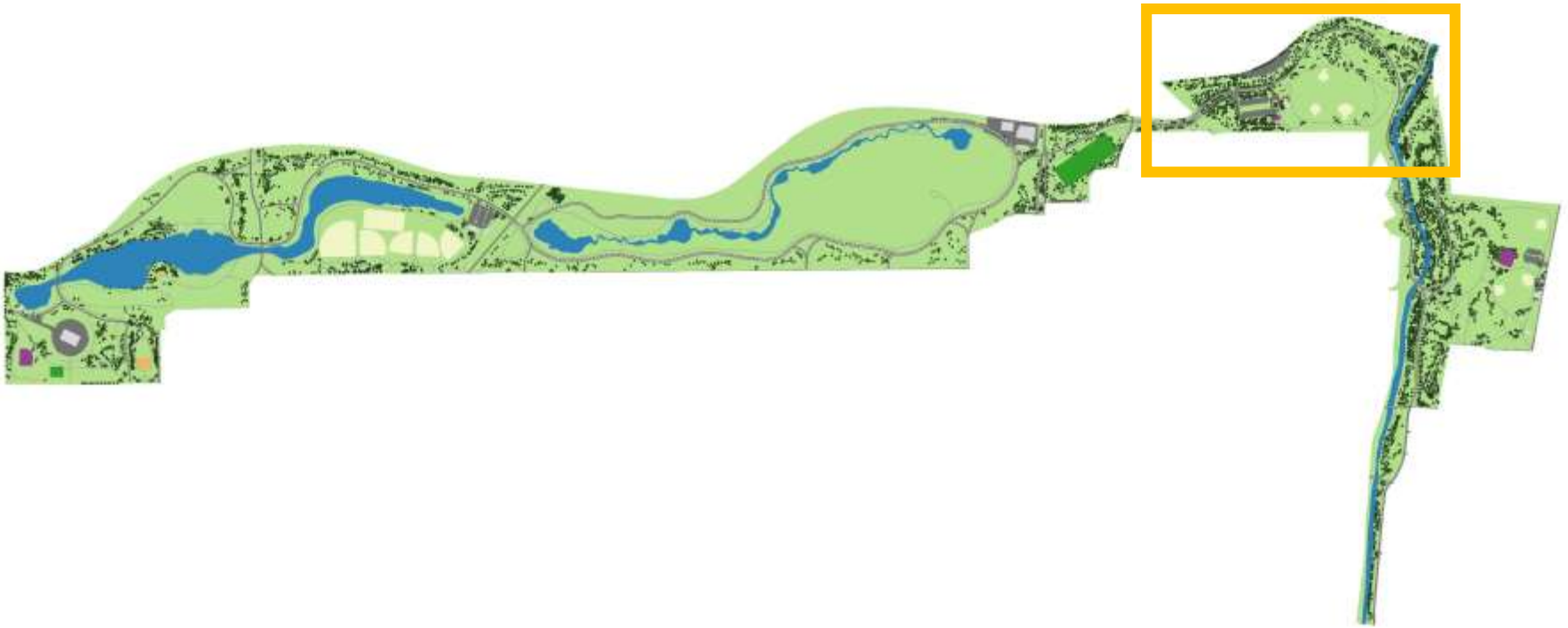

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Vector Data

Branch Brook Park, Newark, New Jersey, USA

0 250 500 750 1000 ft

Imagery derived from satellite orthophotography courtesy of the New Jersey OIT, OGIS (2012-2013).
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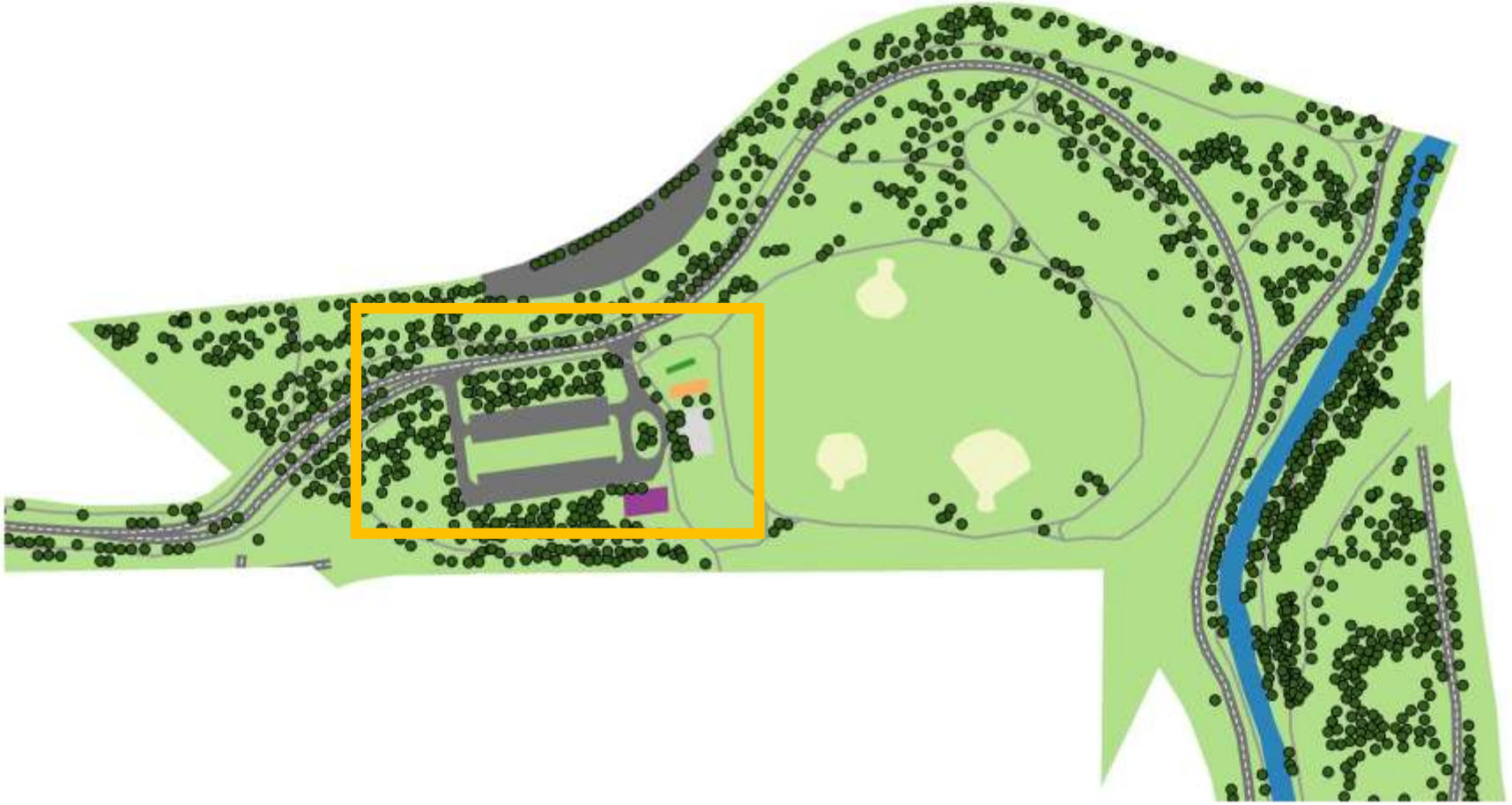
Vector Data

Branch Brook Park, Newark, New Jersey, USA



0 250 500 750 1000 ft

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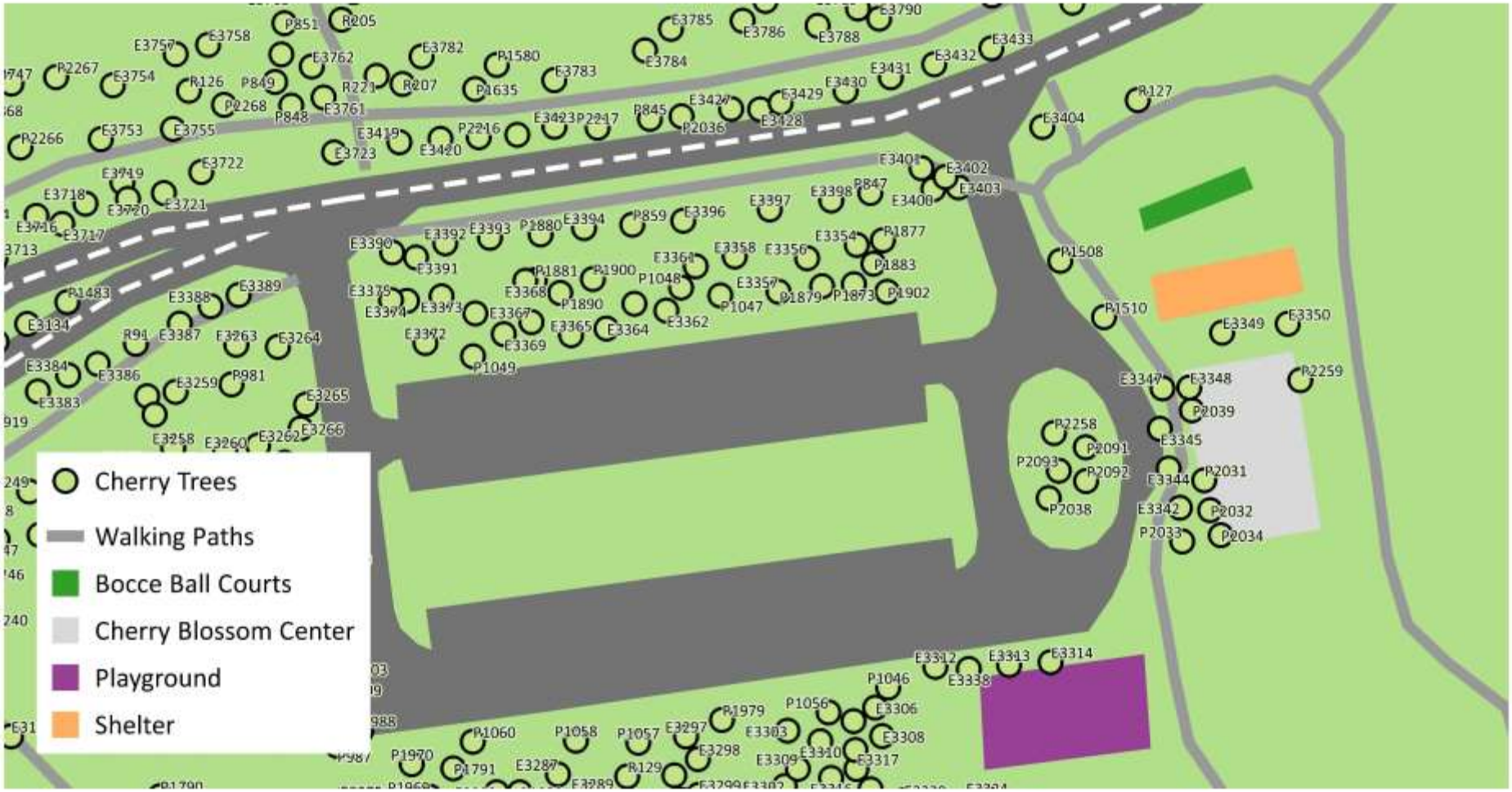

0 50 100 150 200 ft

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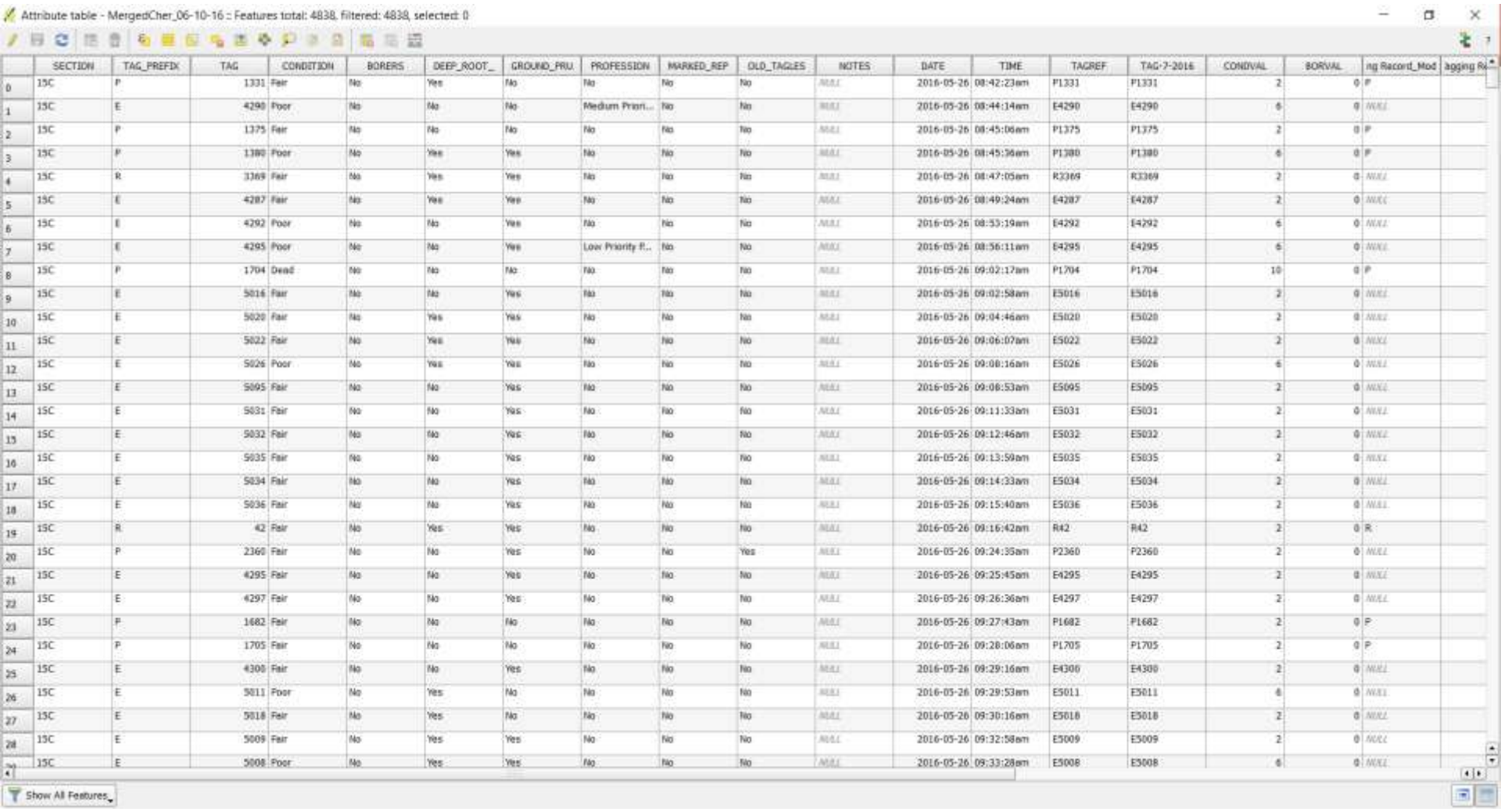
Vector Data

Branch Brook Park, Newark, New Jersey, USA

Vector Data

Attribute Table



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0	15C	P	1331	Fair	No	Yes	No	No	No	No	NULL	2016-05-26	08:42:23am	P1331	P1331	2	0	P	
1	15C	E	4290	Poor	No	No	No	Medium Priori...	No	No	NULL	2016-05-26	08:44:14am	E4290	E4290	6	0	NULL	
2	15C	P	1375	Fair	No	No	No	No	No	No	NULL	2016-05-26	08:45:06am	P1375	P1375	2	0	P	
3	15C	P	1380	Poor	No	Yes	Yes	No	No	No	NULL	2016-05-26	08:45:56am	P1380	P1380	6	0	P	
4	15C	R	3369	Fair	No	Yes	Yes	No	No	No	NULL	2016-05-26	08:47:05am	R3369	R3369	2	0	NULL	
5	15C	E	4287	Fair	No	Yes	Yes	No	No	No	NULL	2016-05-26	08:49:24am	E4287	E4287	2	0	NULL	
6	15C	E	4292	Poor	No	No	Yes	No	No	No	NULL	2016-05-26	08:53:19am	E4292	E4292	6	0	NULL	
7	15C	E	4295	Poor	No	No	Yes	Low Priority P...	No	No	NULL	2016-05-26	08:56:11am	E4295	E4295	6	0	NULL	
8	15C	P	1704	Dead	No	No	No	No	No	No	NULL	2016-05-26	09:02:17am	P1704	P1704	10	0	P	
9	15C	E	5016	Fair	No	No	Yes	No	No	No	NULL	2016-05-26	09:02:58am	E5016	E5016	2	0	NULL	
10	15C	E	5020	Fair	No	Yes	Yes	No	No	No	NULL	2016-05-26	09:04:46am	E5020	E5020	2	0	NULL	
11	15C	E	5022	Fair	No	Yes	Yes	No	No	No	NULL	2016-05-26	09:06:07am	E5022	E5022	2	0	NULL	
12	15C	E	5026	Poor	No	Yes	Yes	No	No	No	NULL	2016-05-26	09:08:16am	E5026	E5026	6	0	NULL	
13	15C	E	5095	Fair	No	No	Yes	No	No	No	NULL	2016-05-26	09:08:53am	E5095	E5095	2	0	NULL	
14	15C	E	5031	Fair	No	No	Yes	No	No	No	NULL	2016-05-26	09:11:33am	E5031	E5031	2	0	NULL	
15	15C	E	5032	Fair	No	No	Yes	No	No	No	NULL	2016-05-26	09:12:46am	E5032	E5032	2	0	NULL	
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17	15C	E	5034	Fair	No	No	Yes	No	No	No	NULL	2016-05-26	09:14:33am	E5034	E5034	2	0	NULL	
18	15C	E	5036	Fair	No	No	Yes	No	No	No	NULL	2016-05-26	09:15:40am	E5036	E5036	2	0	NULL	
19	15C	R	42	Fair	No	Yes	Yes	No	No	No	NULL	2016-05-26	09:16:42am	R42	R42	2	0	R	
20	15C	P	2360	Fair	No	No	Yes	No	No	Yes	NULL	2016-05-26	09:24:35am	P2360	P2360	2	0	NULL	
21	15C	E	4295	Fair	No	No	Yes	No	No	No	NULL	2016-05-26	09:25:45am	E4295	E4295	2	0	NULL	
22	15C	E	4297	Fair	No	No	Yes	No	No	No	NULL	2016-05-26	09:26:36am	E4297	E4297	2	0	NULL	
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26	15C	E	5011	Poor	No	Yes	No	No	No	No	NULL	2016-05-26	09:29:53am	E5011	E5011	6	0	NULL	
27	15C	E	5018	Fair	No	Yes	No	No	No	No	NULL	2016-05-26	09:30:16am	E5018	E5018	2	0	NULL	
28	15C	E	5009	Fair	No	Yes	Yes	No	No	No	NULL	2016-05-26	09:32:58am	E5009	E5009	2	0	NULL	
29	15C	E	5008	Poor	No	Yes	Yes	No	No	No	NULL	2016-05-26	09:33:28am	E5008	E5008	6	0	NULL	

Types of Geographic Data: Raster Data

- Raster data (continuous data):
  - Images
  - Elevation
  - Slope
  - Anything which can be described with a numeric value
  - Arranged in a grid (pixels)

Types of Geographic Data: Raster Data

- Examples:
  - Color satellite imagery
  - Percent live vegetation
- Can be used to perform math:
  - Change in tree canopy cover (old canopy – new canopy)
  - More advanced algorithms

Raster Data: Aerial Imagery

Newark, New Jersey, USA

0 0.25 0.5 0.75 1 mi

Imagery derived from the USDA's National Agricultural Imagery Program. Source imagery acquired July 29, 2015.

Raster Data: Vegetation Index

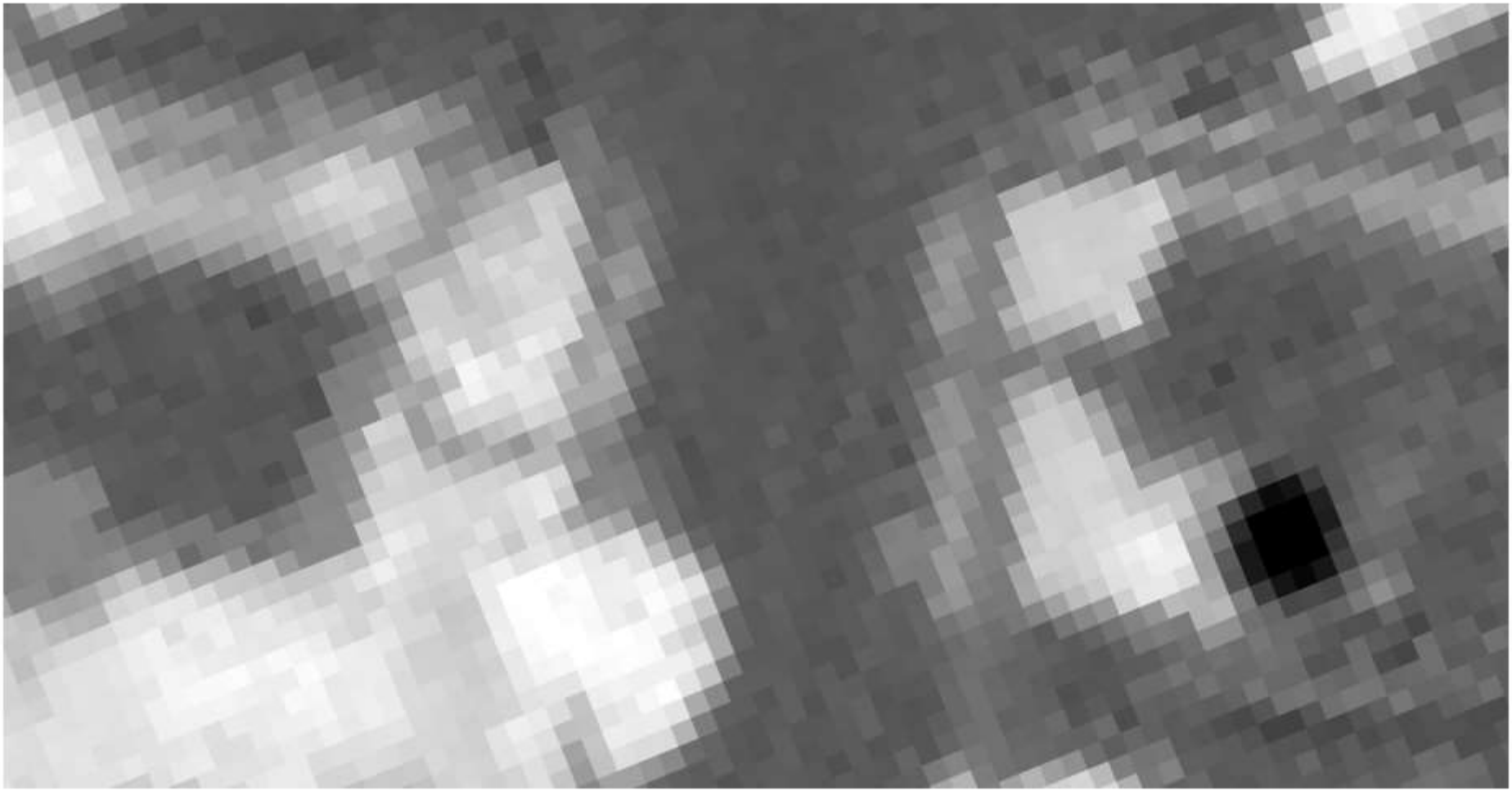
Newark, New Jersey, USA

0 0.25 0.5 0.75 1 mi

Imagery derived from the USDA's National Agricultural Imagery Program. Source imagery acquired July 29, 2015.

Raster Grid Zoomed In

Newark, New Jersey, USA



0 10 20 30 40 ft

Imagery derived from satellite orthophotography courtesy of the New Jersey OIT, OGIS (2012-2013).

Uses for Vector Data in Urban Forestry

- Points data
  - Trees
  - Vacant planting sites
- Lines data
  - Utilities
  - Roads
  - Planting Strips
- Polygons data
  - Structures / Context
  - Blocks of forest

Uses for Vector Data in Urban Forestry

- Sifting through the noise:
  - Showing 5,000 trees is impressive, not very informative.
- Attributes give data meaning!
- Symbolize by color, heatmap, shape, size, etc.
  - Make maps that are **intuitive** and **user-friendly**.

Displaying Vector Data

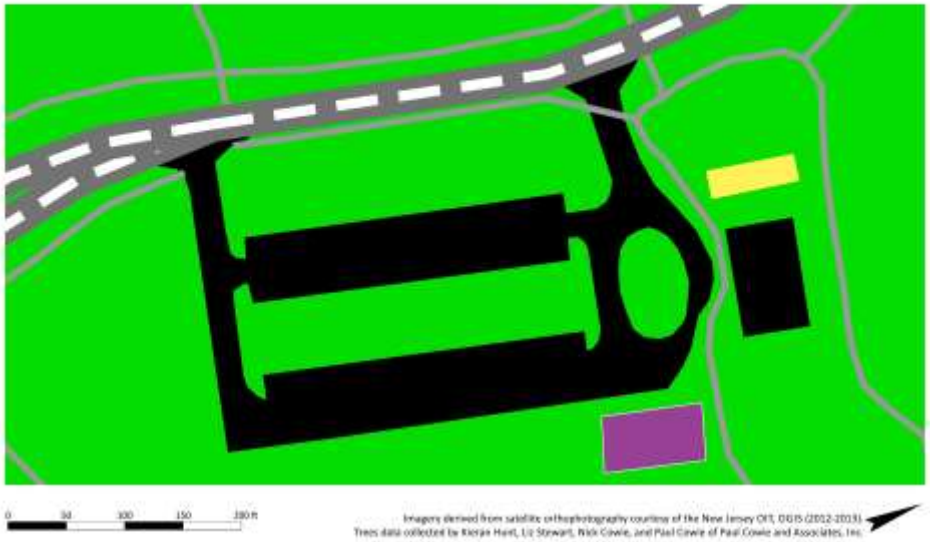
- KNOW YOUR QUESTION
  - Your map will not have purpose if you don't.
- Sift through the noise:
  - Often more useful to **remove** information.
  - **Show only what's needed** to answer a question.

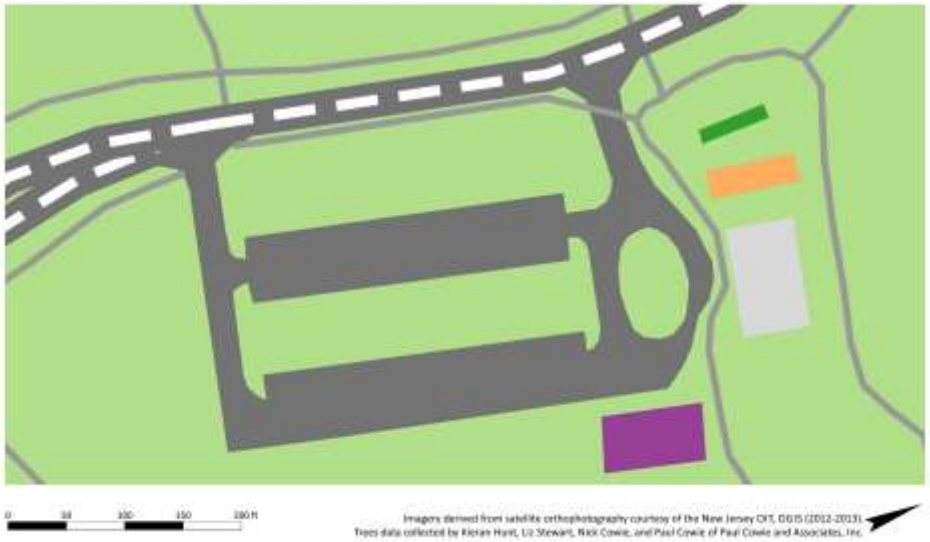
Displaying Vector Data

- Making data useful:
  - Mapmaking combines **technical knowledge** with **aesthetic communication**.
  - Maps must be **readable** and **intuitive**.
  - Gathering information often easier than conveying it.

Displaying Vector Data

- Technically sound maps that are not aesthetically pleasing will seem **less trustworthy** to your client.





Displaying Vector Data

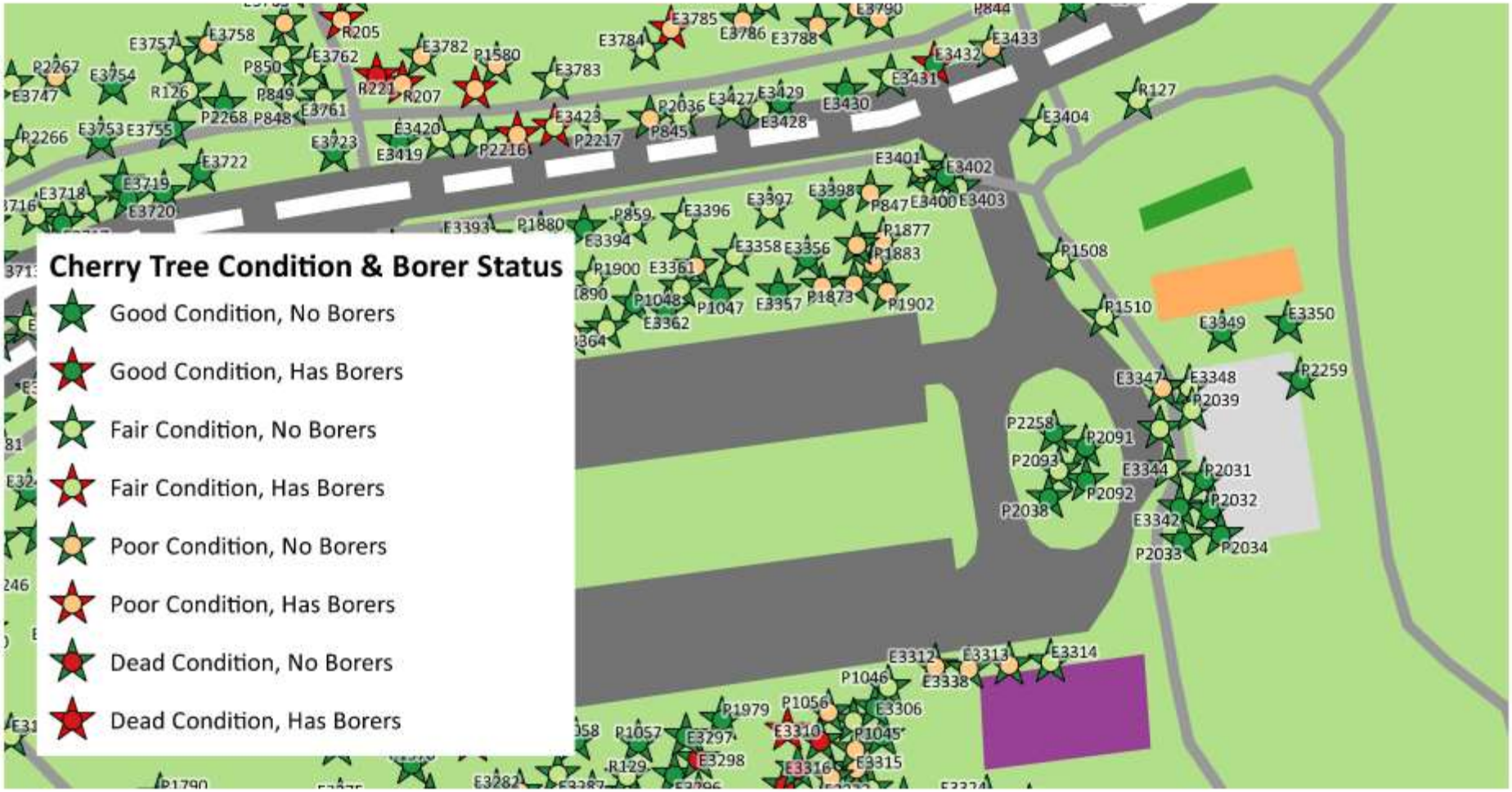
- **This slide has a lot of loud text on it.**
  - I'll bet your first reaction when you saw the slide was not excitement about reading all the text on it.
- There's really **too much** going on on this slide:
  - If there were fewer things, *and their styles matched*, the slide would feel more approachable.
  - **Maps shouldn't be this busy either.**
  - Slides and maps must be **readable** and **intuitive**.
  - Cramming too much information makes them unapproachable and busy.
- **Don't make maps like this slide:**
  - It's better to ***remove*** unnecessary information, displaying only enough to answer our question.
- Too much information makes for busy maps.
  - (And busy slides.)
- **Do you trust me?**

Displaying Vector Data

- Sifting through the noise:
  - Often better to **remove** information, displaying only what we need.
- Too much information makes for busy maps.

Too Much Data!

Branch Brook Park, Newark, New Jersey, USA



Imagery derived from satellite orthophotography courtesy of the New Jersey OIT, OGIS (2012-2013).
Trees data collected by Kieran Hunt, Liz Stewart, Nick Cowie, and Paul Cowie of Paul Cowie and Associates, Inc.

Tree Condition Data

Branch Brook Park, Newark, New Jersey, USA

Borers Data

Branch Brook Park, Newark, New Jersey, USA

Borers Points

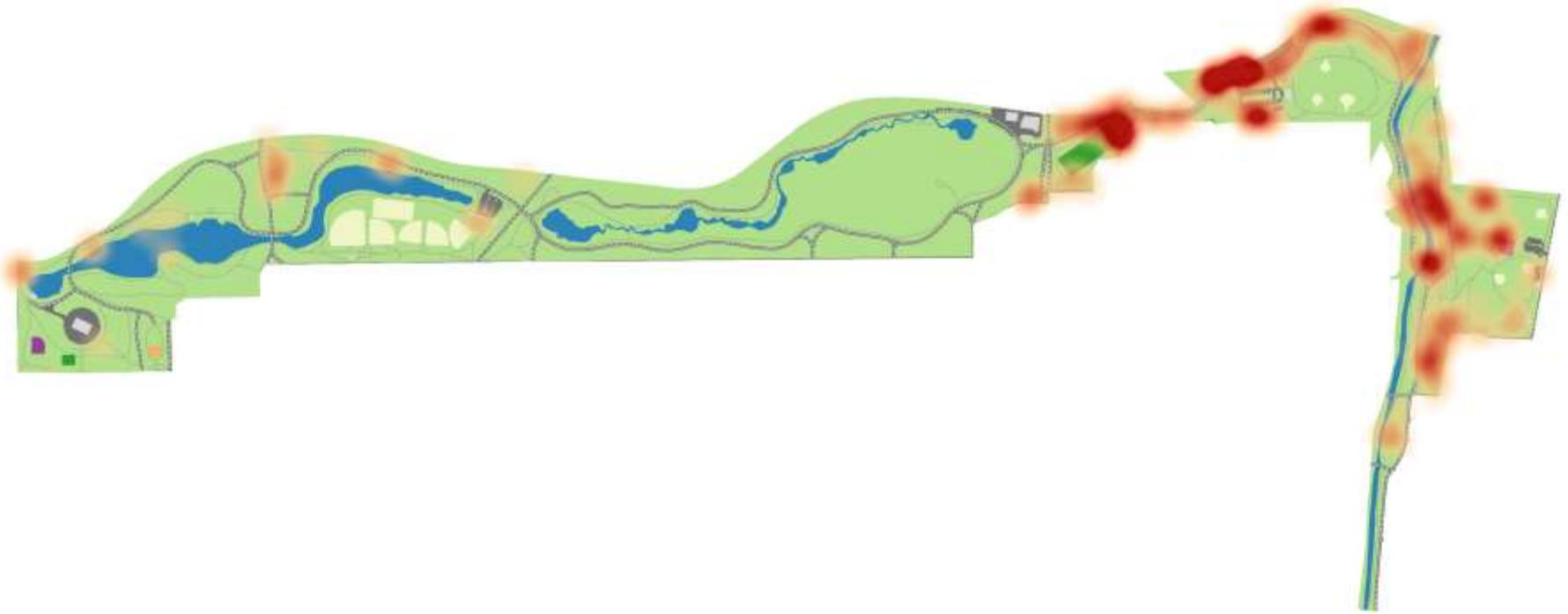
Branch Brook Park, Newark, New Jersey, USA

0 0.25 0.5 0.75 1 mi

Imagery derived from satellite orthophotography courtesy of the New Jersey OIT, OGIS (2012-2013).
Trees data collected by Kieran Hunt, Liz Stewart, Nick Cowie, and Paul Cowie of Paul Cowie and Associates, Inc.

Borers Heatmap

Branch Brook Park, Newark, New Jersey, USA



0 0.25 0.5 0.75 1 mi

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Condition Heatmap

Branch Brook Park, Newark, New Jersey, USA

0 0.25 0.5 0.75 1 mi

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Displaying Raster Data

- Sifting through the noise:
  - Again, often better to **only show what we need** to see to answer a question.
- Aesthetic communication:
  - Raster data consists purely of numerical values.
  - How do we display that in a **meaningful** and **aesthetically pleasing** way?

Aerial Imagery

Newark, New Jersey, USA

0 0.25 0.5 0.75 1 mi

Imagery derived from the USDA's National Agricultural Imagery Program. Source imagery acquired July 29, 2015.

Vegetation Index

Newark, New Jersey, USA

0 0.25 0.5 0.75 1 mi

Imagery derived from the USDA's National Agricultural Imagery Program. Source imagery acquired July 29, 2015.

Vegetation Index, Resymbolized

Newark, New Jersey, USA

0 0.25 0.5 0.75 1 mi

Imagery derived from the USDA's National Agricultural Imagery Program. Source imagery acquired July 29, 2015.

Advanced Raster Data Processes

- Raster data can be processed to show specific information.
- Normalized Difference Vegetation Index (NDVI) [1]:
  - Calculated from red (R) and near infrared (NIR) bands of light.
  - NDVI = (NIR-R)/(NIR+R)
  - Useful for showing areas in need of tree canopy; helps manage **equity** in an urban forest.

1. Kriegler, F.J., Malila, W.A., Nalepka, R.F., and Richardson, W. (1969) 'Preprocessing transformations and their effects on multispectral recognition.' Proceedings of the Sixth International Symposium on Remote Sensing of Environment, p. 97-131.

Aerial Imagery

Newark, New Jersey, USA

0 0.25 0.5 0.75 1 mi

Imagery derived from the USDA's National Agricultural Imagery Program. Source imagery acquired July 29, 2015.

NDVI (Gray to Green)

Newark, New Jersey, USA

0 0.25 0.5 0.75 1 mi

Imagery derived from the USDA's National Agricultural Imagery Program. Source imagery acquired July 29, 2015.

Combining Vector & Raster Data: A Case Study in Paramus, NJ

- Vector Data:
  - Roads
    - Used to approximate public right-of-way
- Raster Data:
  - Aerial Imagery
    - Processed to Vegetation Index
    - Further Processed to Vacant Lawns
    - Used to generate possible planting sites

Aerial Imagery

Paramus, New Jersey, USA

0 100 200 300 400 ft

Aerial and processed imagery derived from the USDA's National Agricultural Imagery Program.
Roads map generated from the US Census Bureau "TIGER/Line Shapefile, 2014, state, New Jersey, Primary and Secondary Roads State-based Shapefile".

Roads

Paramus, New Jersey, USA

0 100 200 300 400 ft

Aerial and processed imagery derived from the USDA's National Agricultural Imagery Program.
Roads map generated from the US Census Bureau "TIGER/Line Shapefile, 2014, state, New Jersey, Primary and Secondary Roads State-based Shapefile".

Buffered Roads

Paramus, New Jersey, USA

0 100 200 300 400 ft

Aerial and processed imagery derived from the USDA's National Agricultural Imagery Program.
Roads map generated from the US Census Bureau "TIGER/Line Shapefile, 2014, state, New Jersey, Primary and Secondary Roads State-based Shapefile".

Buffered Roads with NDVI

Paramus, New Jersey, USA

0 100 200 300 400 ft

Aerial and processed imagery derived from the USDA's National Agricultural Imagery Program.
Roads map generated from the US Census Bureau "TIGER/Line Shapefile, 2014, state, New Jersey, Primary and Secondary Roads State-based Shapefile".

NDVI Clipped to Roads

Paramus, New Jersey, USA

0 100 200 300 400 ft

Aerial and processed imagery derived from the USDA's National Agricultural Imagery Program.
Roads map generated from the US Census Bureau "TIGER/Line Shapefile, 2014, state, New Jersey, Primary and Secondary Roads State-based Shapefile".

NDVI Mid-Fifth

Paramus, New Jersey, USA

0 100 200 300 400 ft

Aerial and processed imagery derived from the USDA's National Agricultural Imagery Program.
Roads map generated from the US Census Bureau "TIGER/Line Shapefile, 2014, state, New Jersey, Primary and Secondary Roads State-based Shapefile".

NDVI Mid-Fifth Over NIR

Paramus, New Jersey, USA

0 100 200 300 400 ft

Aerial and processed imagery derived from the USDA's National Agricultural Imagery Program.
Roads map generated from the US Census Bureau "TIGER/Line Shapefile, 2014, state, New Jersey, Primary and Secondary Roads State-based Shapefile".

Sieved

Paramus, New Jersey, USA

0 100 200 300 400 ft

Aerial and processed imagery derived from the USDA's National Agricultural Imagery Program.
Roads map generated from the US Census Bureau "TIGER/Line Shapefile, 2014, state, New Jersey, Primary and Secondary Roads State-based Shapefile".

Original Imagery

Paramus, New Jersey, USA

0 100 200 300 400 ft

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Roads map generated from the US Census Bureau "TIGER/Line Shapefile, 2014, state, New Jersey, Primary and Secondary Roads State-based Shapefile".

Calculated Lawns

Paramus, New Jersey, USA

0 100 200 300 400 ft

Aerial and processed imagery derived from the USDA's National Agricultural Imagery Program.
Roads map generated from the US Census Bureau "TIGER/Line Shapefile, 2014, state, New Jersey, Primary and Secondary Roads State-based Shapefile".

Auto-Generated Vacant Sites

Paramus, New Jersey, USA

0 100 200 300 400 ft

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Roads map generated from the US Census Bureau "TIGER/Line Shapefile, 2014, state, New Jersey, Primary and Secondary Roads State-based Shapefile".

Auto-Generated Vacant Sites

Paramus, New Jersey, USA

0 0.25 0.5 0.75 1 mi

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It’s Not Perfect!

Paramus, New Jersey, USA

0 50 100 150 200 mi

Aerial and processed imagery derived from the USDA's National Agricultural Imagery Program.
Roads map generated from the US Census Bureau "TIGER/Line Shapefile, 2014, state, New Jersey, Primary and Secondary Roads State-based Shapefile".

Vacant Sites, Uncorrected

Paramus, New Jersey, USA

0 50 100 150 200 mi

Aerial and processed imagery derived from the USDA's National Agricultural Imagery Program.
Roads map generated from the US Census Bureau "TIGER/Line Shapefile, 2014, state, New Jersey, Primary and Secondary Roads State-based Shapefile".

Vacant Sites, Corrected

Paramus, New Jersey, USA

0 50 100 150 200 mi

Aerial and processed imagery derived from the USDA's National Agricultural Imagery Program.
Roads map generated from the US Census Bureau "TIGER/Line Shapefile, 2014, state, New Jersey, Primary and Secondary Roads State-based Shapefile".

Broad-Scale Management

Paramus, New Jersey, USA

0 0.25 0.5 0.75 1 mi

Aerial and processed imagery derived from the USDA's National Agricultural Imagery Program.
Roads map generated from the US Census Bureau "TIGER/Line Shapefile, 2014, state, New Jersey, Primary and Secondary Roads State-based Shapefile".

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    - Used to generate possible planting sites

Using Geomatics in Urban Forestry

- Using both vector and raster data to answer questions.
- Know your question before you start!
  - Needed to collect appropriate data.
  - Maps will not have purpose if no goal in mind.
- Sift through the noise:
  - Often better to **remove** information.

Using Geomatics in Urban Forestry

- Making data useful:
  - Mapmaking combines **technical knowledge** with **aesthetic communication**.
  - Maps must be **readable** and **intuitive.**
  - Gathering technical information often easier than conveying to the layperson.
- Maps that are **not aesthetically pleasing** will seem **less trustworthy** to your client.

The Data is Out There

- NAIP Imagery
  - https://www.fsa.usda.gov/programs-and-services/aerial-photography/imagery-programs/naip-imagery/
- Land Cover Raster Data:
  - http://www.mrlc.gov/
- US Census Bureau Roads Data:
  - https://www.census.gov/geo/maps-data/data/tiger-line.html
- Most states have a dedicated GIS website
  - Land Use / Land Cover Imagery
  - Roads
  - Watersheds
  - Much more

The Tools are Out There

- GIS Software:
  - ESRI ArcGIS (costly, but arguably the best)
  - Quantum GIS (QGIS) (open-source, less user-friendly)
- Useful Reading:
  - “GIS Fundamentals” by Paul Bolstad
  - “Remote Sensing of the Environment: An Earth Resource Perspective” by John R. Jensen
  - “Designing Better Maps: A Guide for GIS Users” by Cynthia A. Brewer
- Classes / certificates at local colleges.

The Broader Picture

- Geomatics and GIS are revolutionizing our industry.
- Technology can improve our management.
- Some questions cannot be answered effectively without geographic information.
- This is the future of our field – this is just the beginning!
- If you don’t do it, someone else will!

Questions?